Using deep-sea observatories to identify ocean noise trends

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« Time-series analysis in Marine science and applications for industry »
Conference in Logonna-Daoulas, France, 17-22 sept. 2012

Overview

- Introduction LAB
- Using deep-sea observatories
  - Listen to the Deep Ocean Environment
  - Acoustic Event Detection
- Noise Measurements
  - What should be measured?
  - How should it be measured?
  - Quantifying noise contribution versus exceeding a threshold

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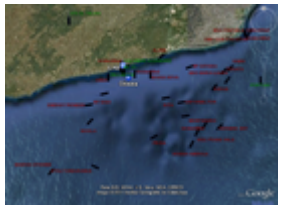
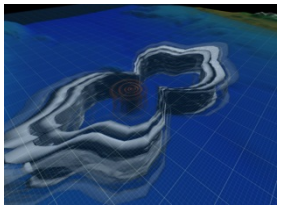
Introduction LAB

Environmental Monitoring



Noise Assessment and Modelling



Physiological Affects

Acoustic Sensing

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Deep Sea Observatories

- Software framework to analyse and present acoustic data in real-time
- Developed under the ESONET
- Currently processing data from
  - OBSEA
  - ANTARES
  - NEMO
  - Shannon Estuary
  - NEPTUNE
  - JAMSTEC
  - CTBTO (offline)
  - VENUS pending

Listen to the Deep Ocean Environment

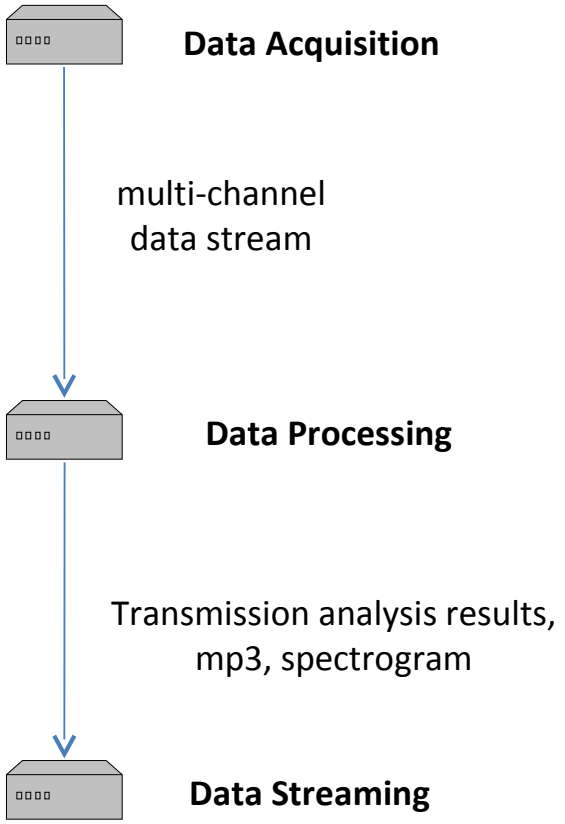
LIDO data analysis includes

- Measurement of noise in bands of interest
- Detection of impulsive signals
- Detection of short tonal signals
- Classification of detected acoustic events
- Localisation of acoustic sources
- Tracking of shipping traffic through AIS

Under development:

- Source level estimation
- Density estimation

Listen to the Deep Ocean Environment

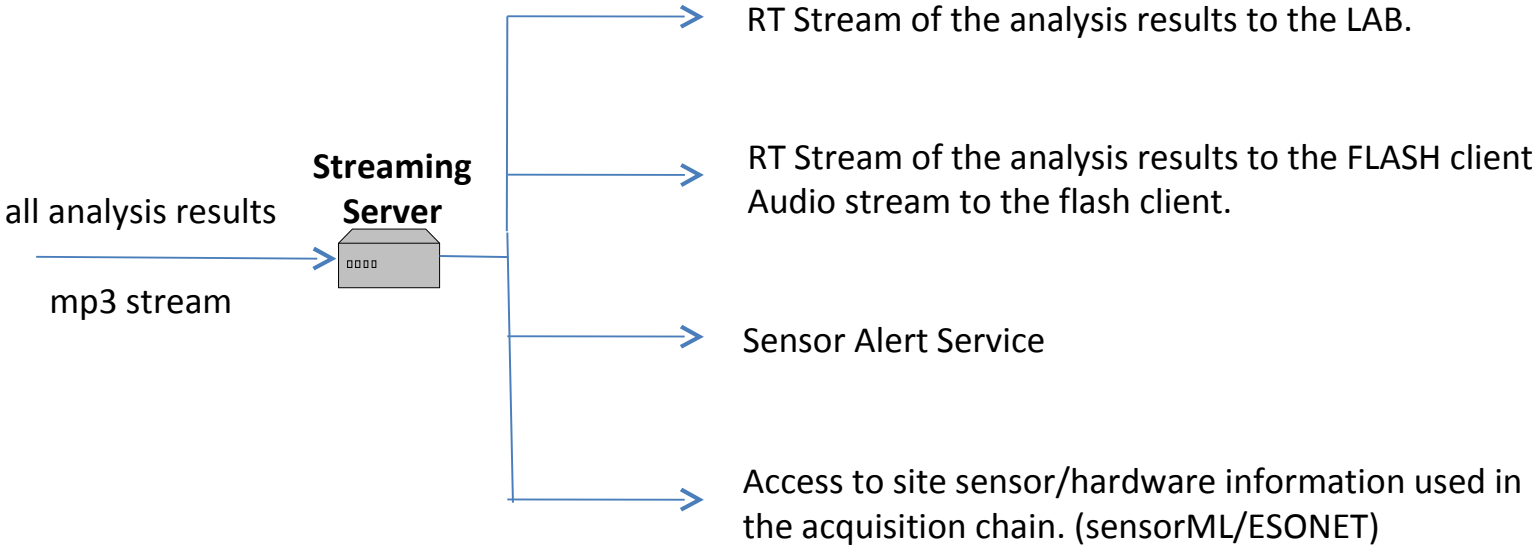


In most cases data is acquired by the platform owner and made available to LIDO.

Data is processed locally as much as possible to limit bandwidth usage.

Analysis results are made publicly available.

Listen to the Deep Ocean Environment



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www.listentothedeep.net

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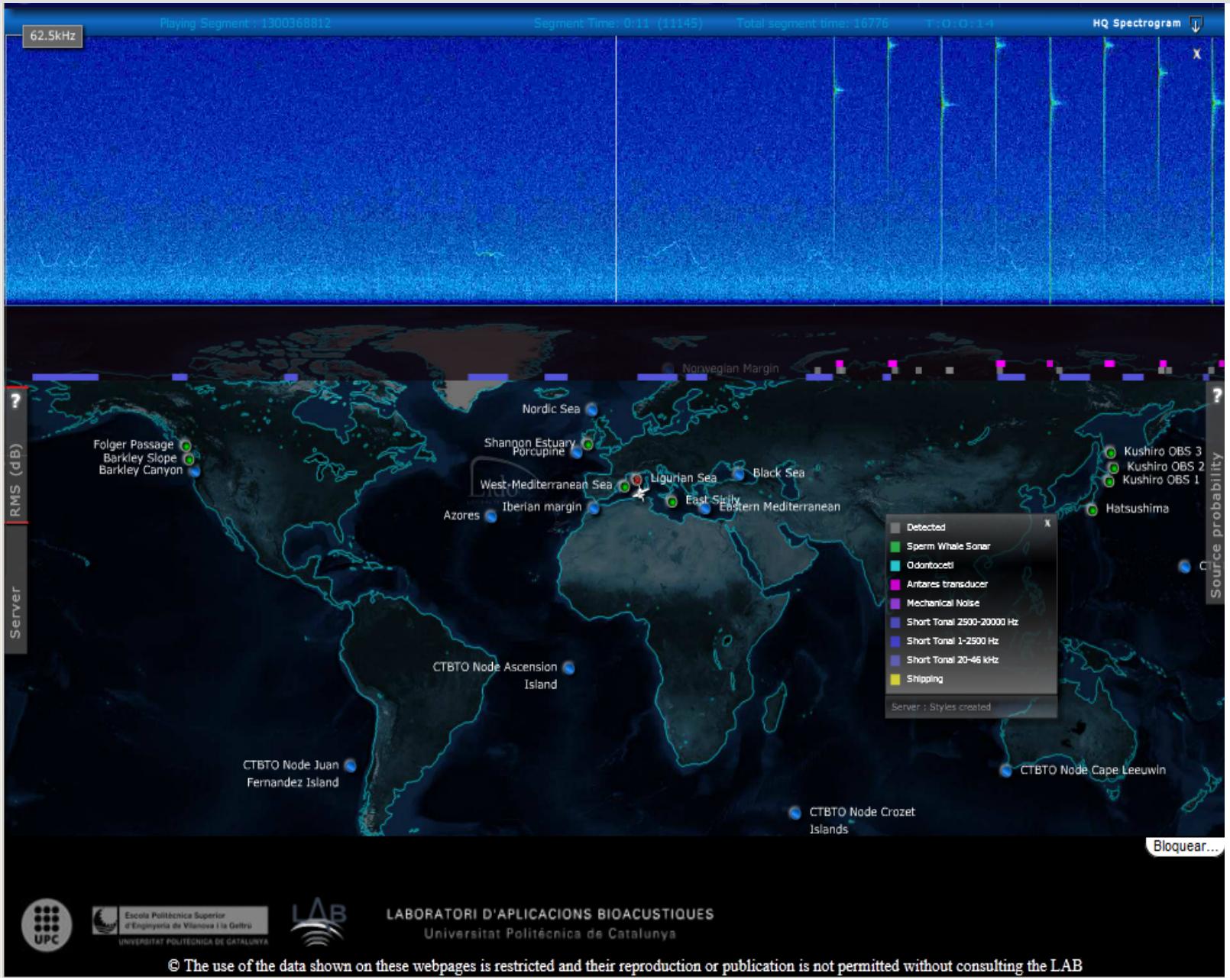

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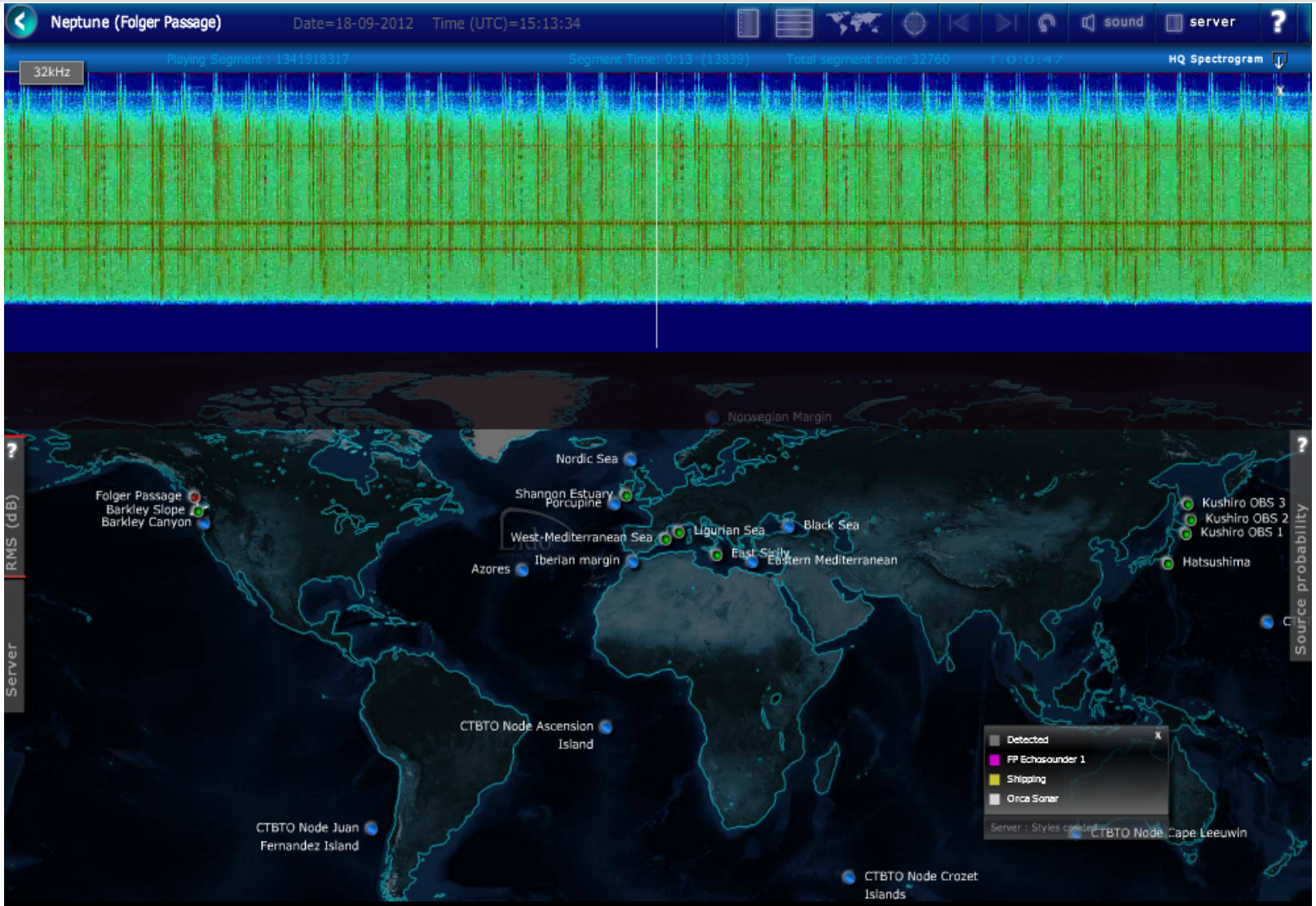

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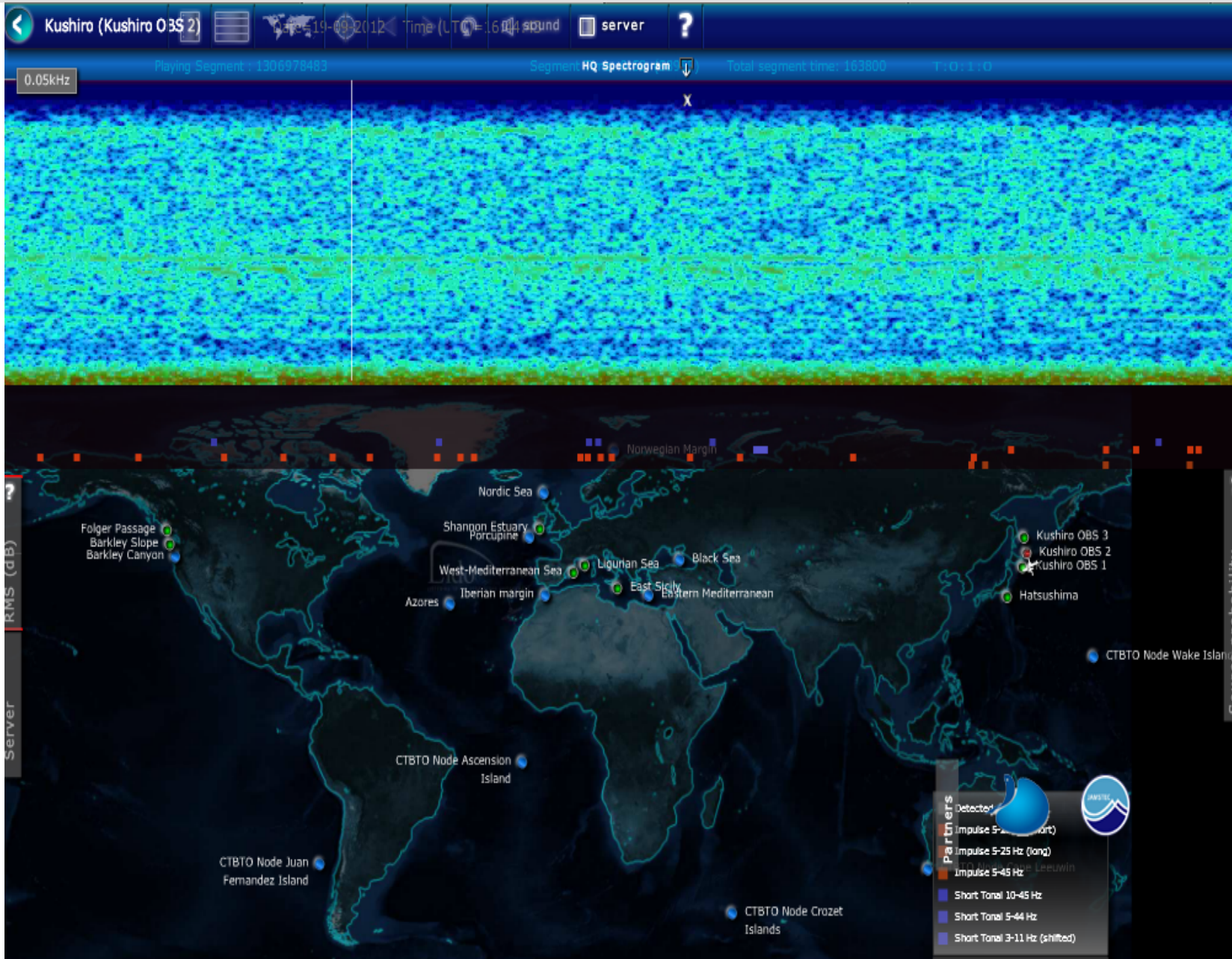
Acoustic Event Detection



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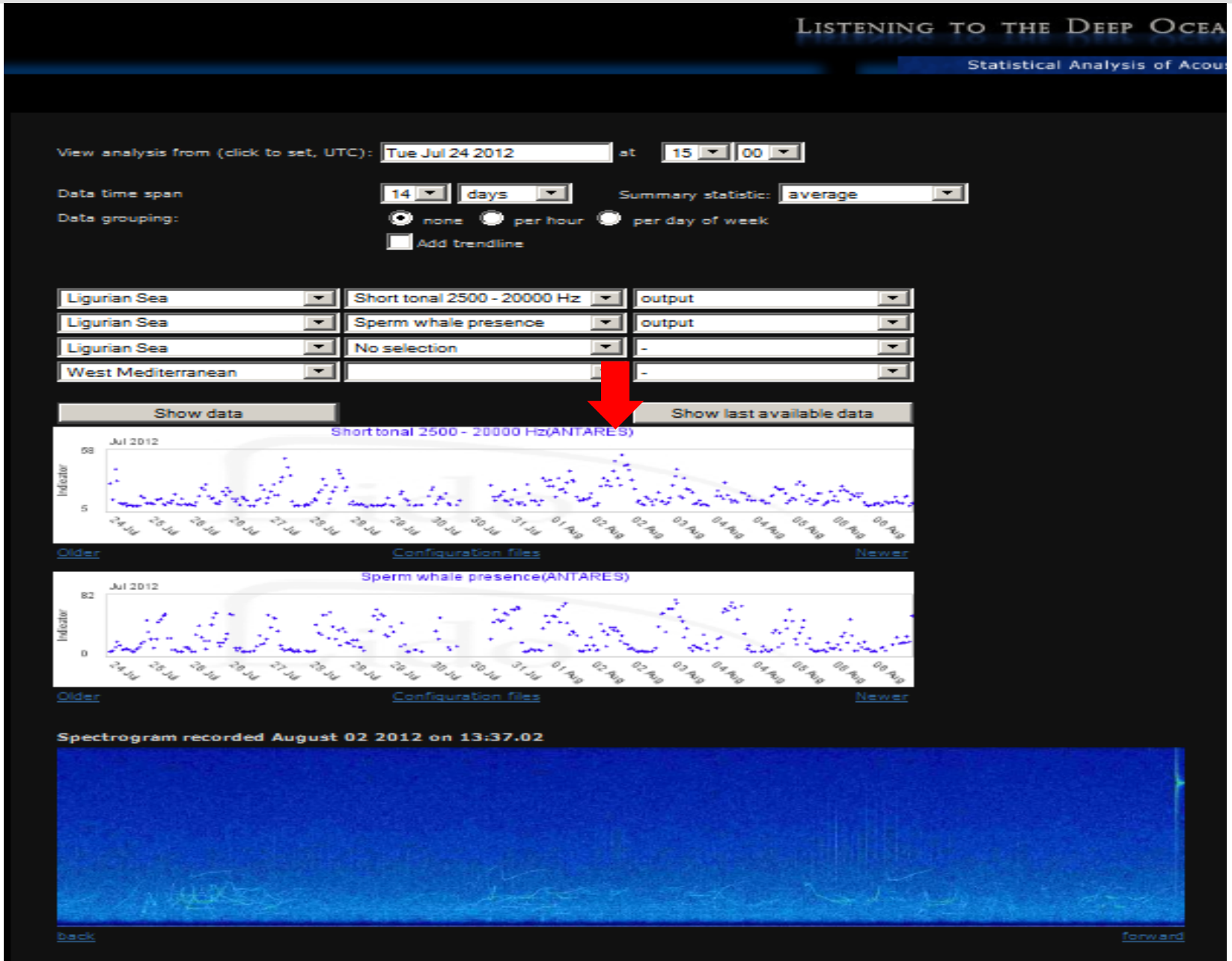

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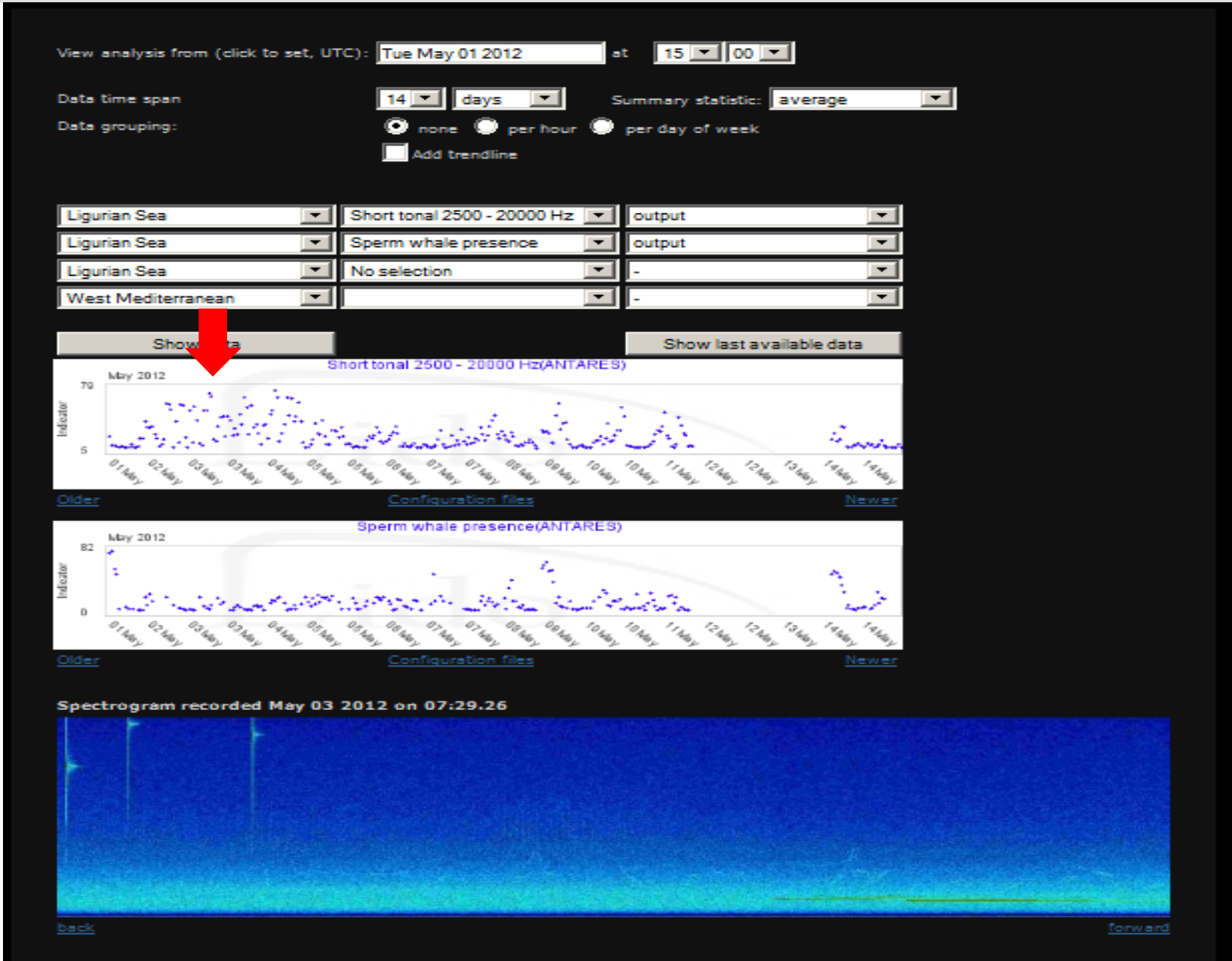

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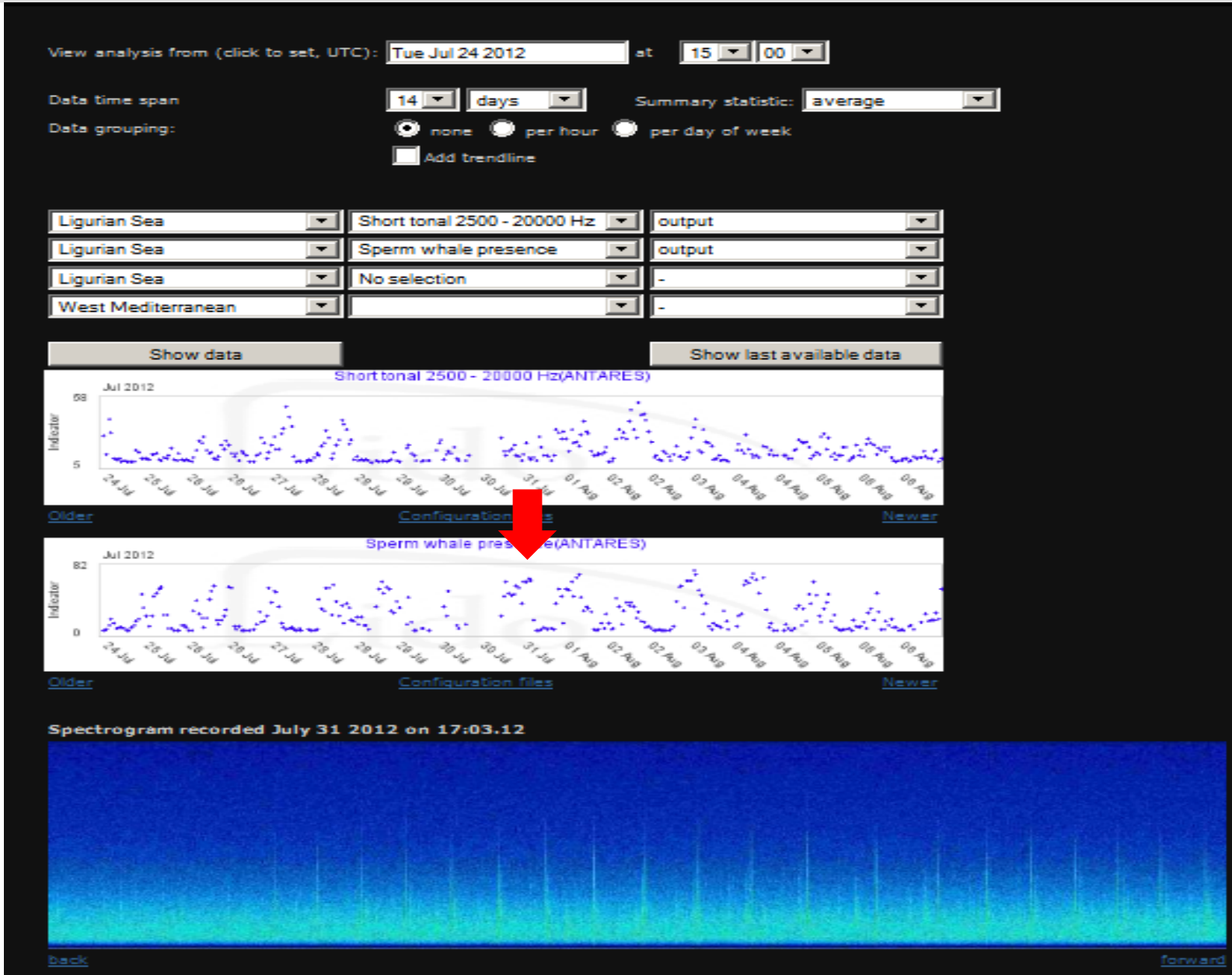

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Acoustic Event Detection

View analysis from (click to set, UTC): Sat Sep 26 2009 at 07 15

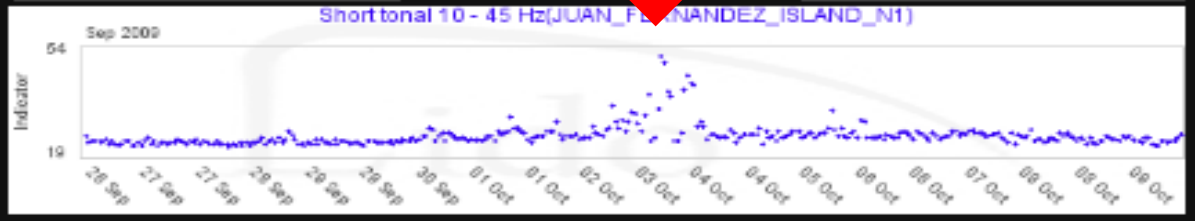
Data time span 14 days Summary statistic: average

Data grouping: none per hour per day of week

Add trendline

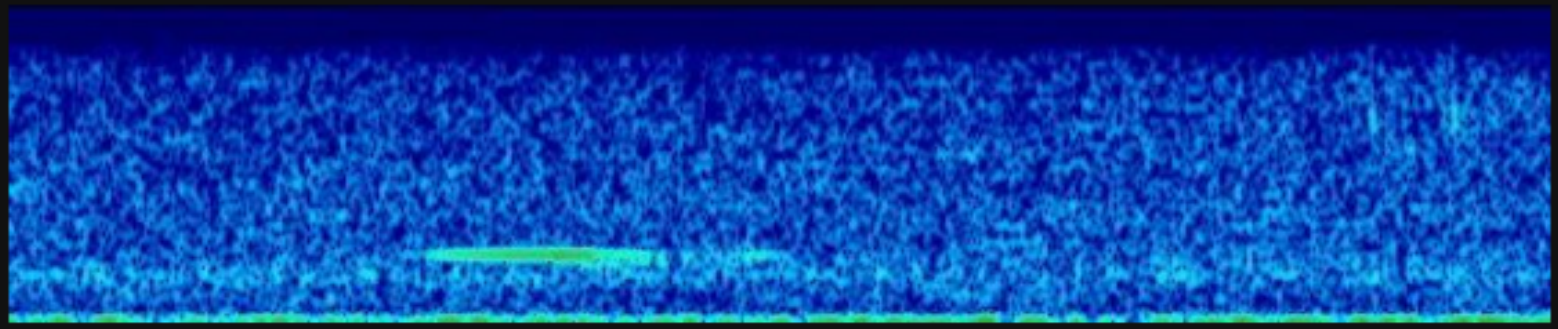
Juan Fernandez Island N1	Short tonal 10 - 45 Hz	output
Ligurian Sea	No selection	-
Ligurian Sea	No selection	-
West Mediterranean		-

Show data Show last available data



Older Configuration files Newer

Spectrogram recorded October 03 2009 on 15:42.05



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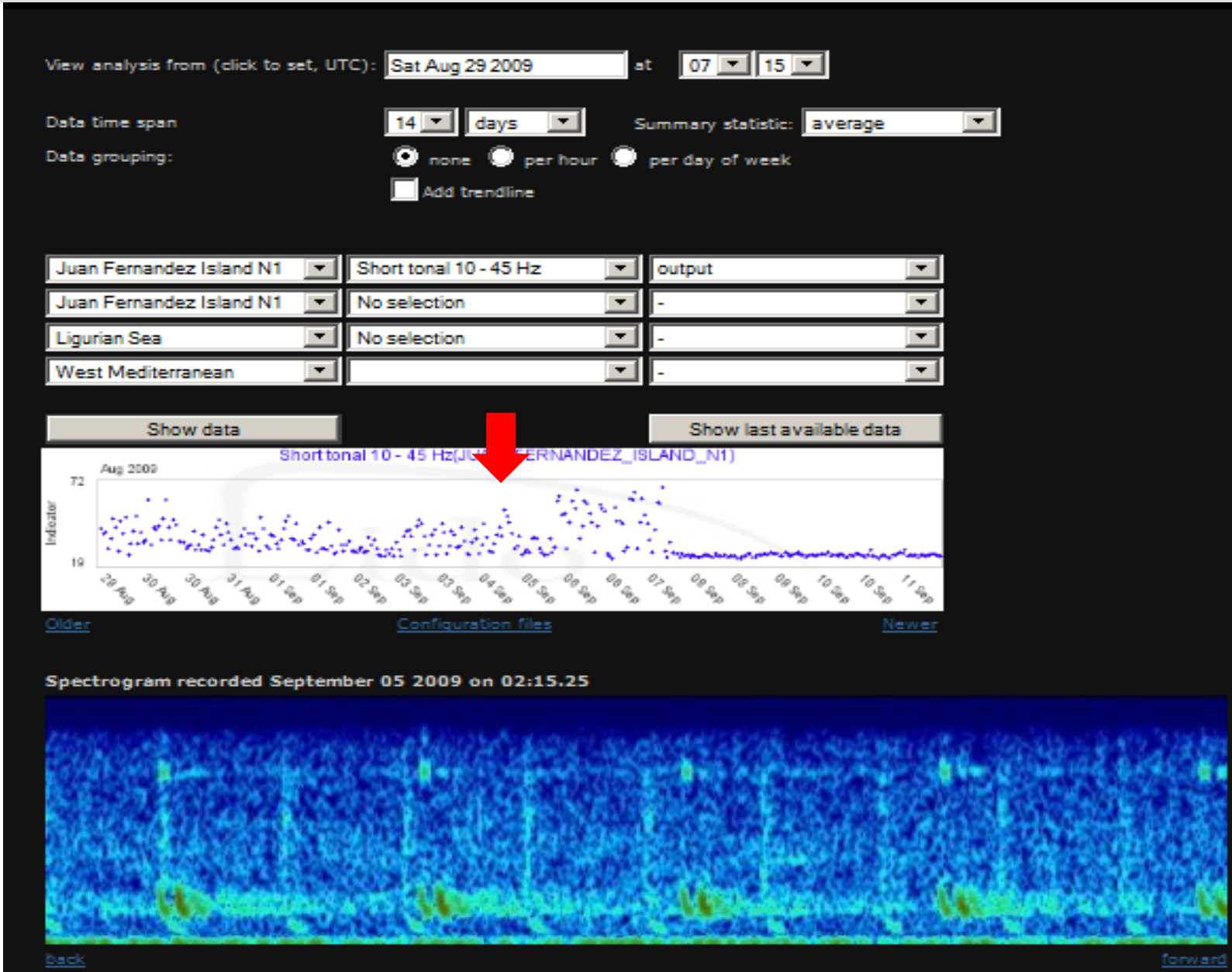
Acoustic Event Detection



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Acoustic Event Detection

View analysis from (click to set, UTC): Sun Feb 21 2010 at 05 15

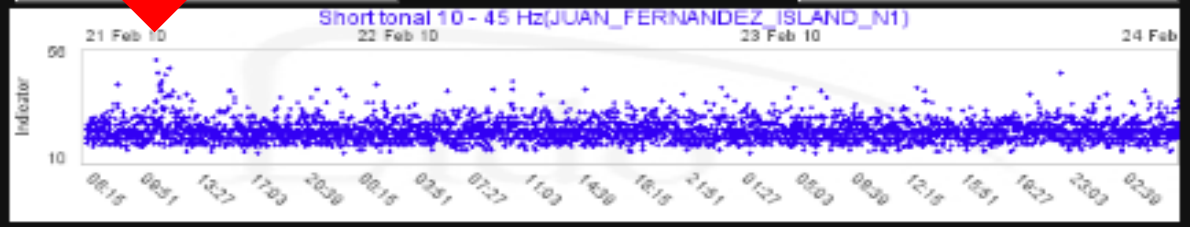
Data time span 3 days Summary statistic: average

Data grouping: none per hour per day of week

Add trendline

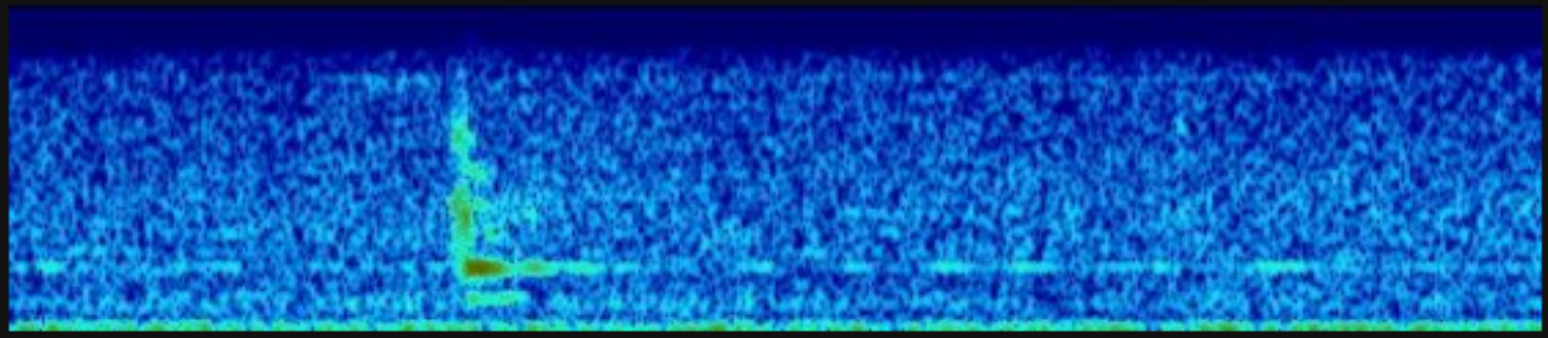
Juan Fernandez Island N1	Short tonal 10 - 45 Hz	output
Juan Fernandez Island N1	No selection	-
Ligurian Sea	No selection	-
West Mediterranean		-

ow data | Show last available data



Older | Configuration files | Newer

Spectrogram recorded February 21 2010 on 11:12.50



back | forward

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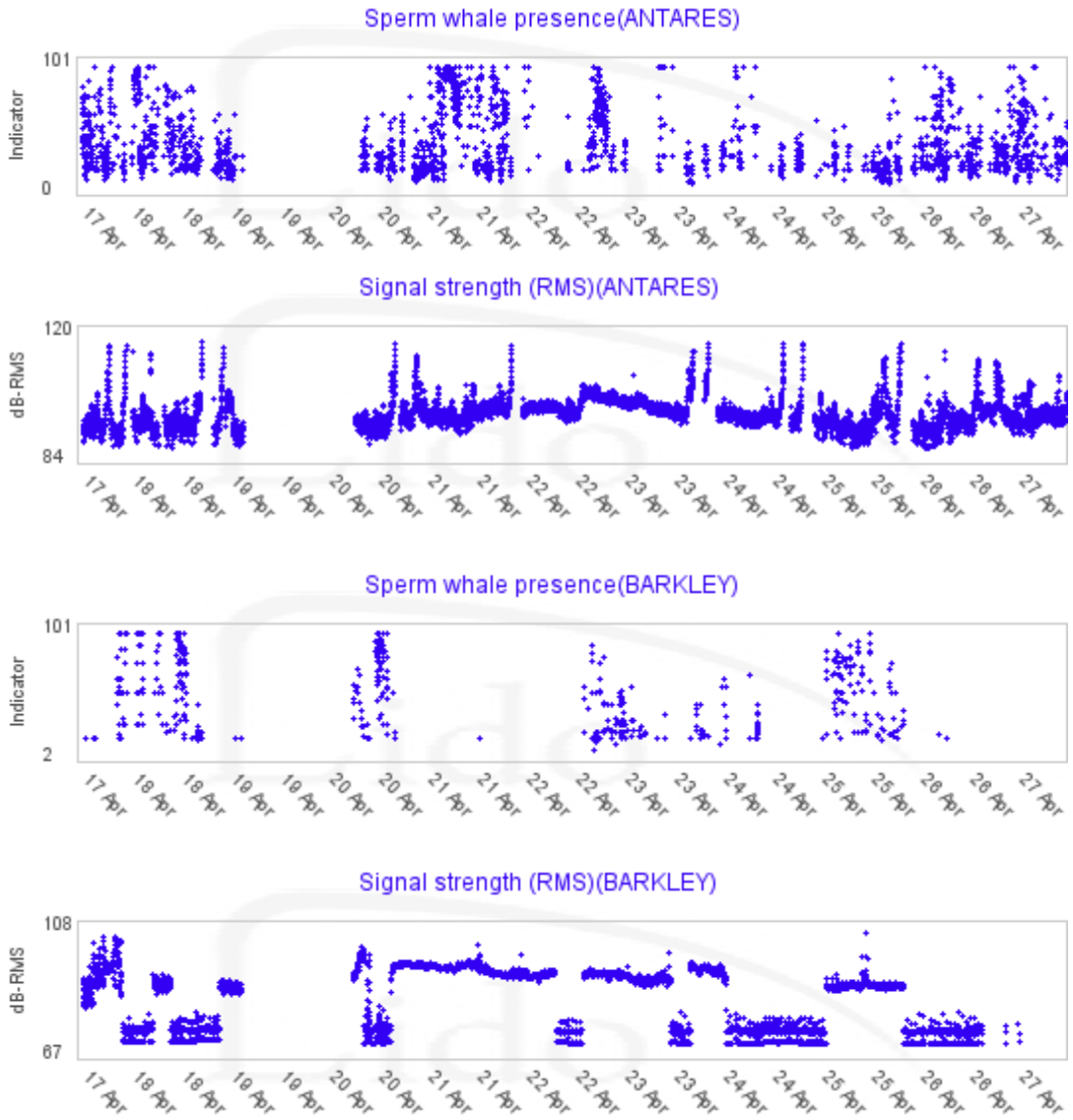
Noise Measurement



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Noise Measurements

How to measure noise ?

- Duration
- Intensity
- Frequency

When can noise be considered harmful ?

- Audiograms only available for a few marine mammal species
- Hearing most sensitive in vocalization range?
- Fishes, cephalopods, bivalves?

Noise Measurements

Which frequencies need to be measured, which thresholds set?

Low frequencies (63, 125 Hz) will affect fish, cephalopods, certain fin whales.

Measuring around 5 kHz will give indications on the effect on dolphin communication.

Measuring around 15 kHz may indicate problems for sperm whale sonar.

Measuring around 40 kHz may indicate problems for beaked whales.

Measuring around 130 kHz may indicate problems for harbour porpoises.

Higher frequencies will only provide very local information.

<u>It is not known what levels can be acceptable.</u>

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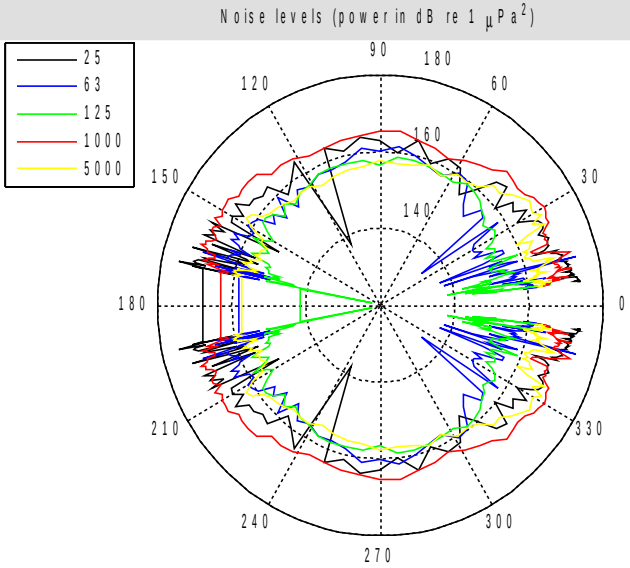
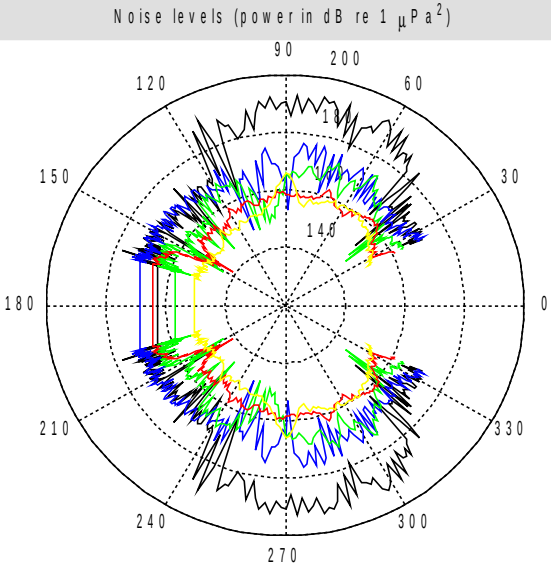
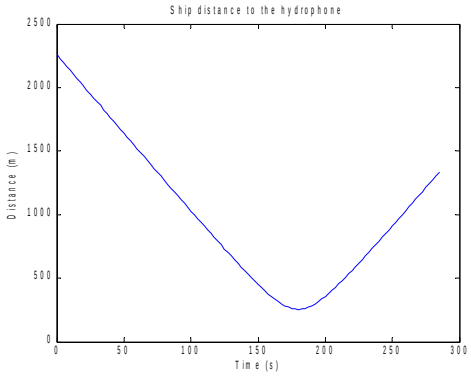
Noise Measurements

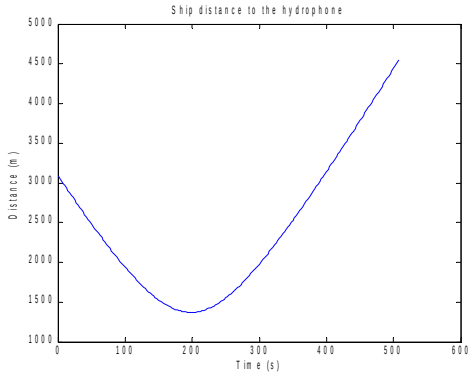




Fast ferry



Cargo ship



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Noise Measurements

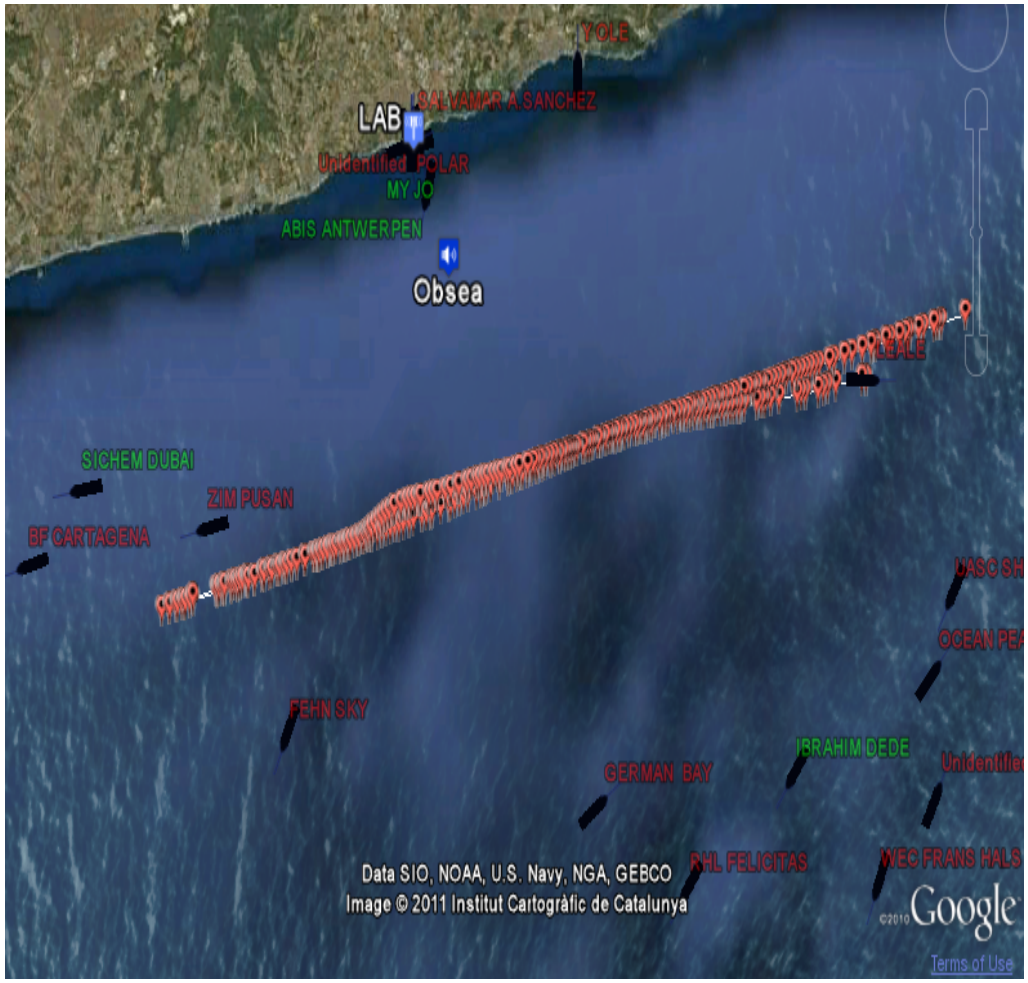
Marine Strategy Framework Directive 11

1.Count the number of expected impulses based on modelling.

2.Measure noise in third octave bands centred on 63 and 125 Hz

- Depending on environment, measure can be valid for large area.
- Includes shipping noise, pile driving, explosions, etc.

Source Level Estimation



LEALE

MMSI: 247238700

Latest information received on: 5th June 09:31:32 AM

Speed: 12.600 knots

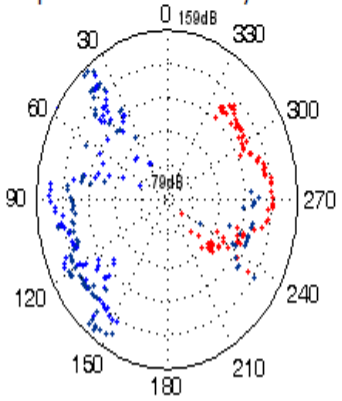
Longitude: 1.98573

Latitude: 41.14863

Status: Under way using engine

Shiptype: Tanker

Ship acoustic directivity*:



3rd-octave level 63 Hz
3rd-octave level 125 Hz

Difficulties for OBSEA: distance to hydrophone, ships ‘parked’ nearby.

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Noise Measurements

How to estimate an average noise level?

RMS sound pressure $s = \sqrt{\frac{1}{N}\sum_i^N {p_i}^2}$

- Arithmetic mean $\mathrm{AM} = 10\ \log\frac{1}{W}\ \sum_i^W {s^2}_i$
- Geometric mean $GM = \frac{1}{W}\sum_i^W 10 \log {s^2}_i$
- Median

Noise Measurements

Arithmetic mean $\mathrm{AM} = 10 \log \frac{1}{W} \sum_i^W s^2{}_i$

- Natural extension of the RMS measurement
- Invariant to window size N
- Not robust against data outliers
- Not robust against processing errors

Noise Measurements

Geometric mean $GM = \frac{1}{W}\sum_i^W 10\log s^2{}_i$

- Fast to compute when data is stored in dB
- Robust against outliers
- Not robust against system errors
- Value depends on initial window N

Noise Measurements

Median

- Robust against outliers, system errors
- Value depends on initial window N
- Sorting operation can be slow
- Always needs all values, ‘median of medians’ can be questionable.

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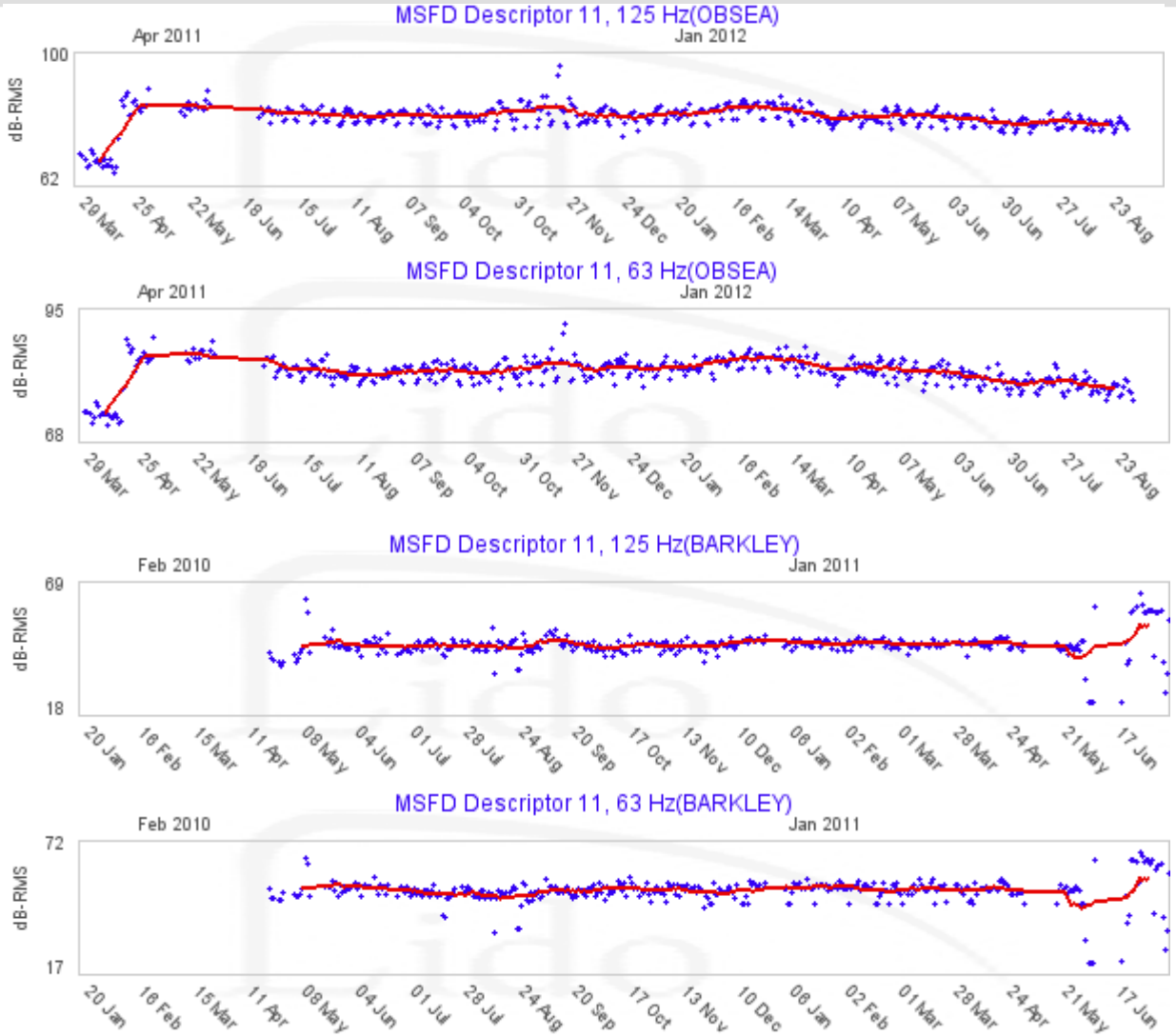
Noise Measurements



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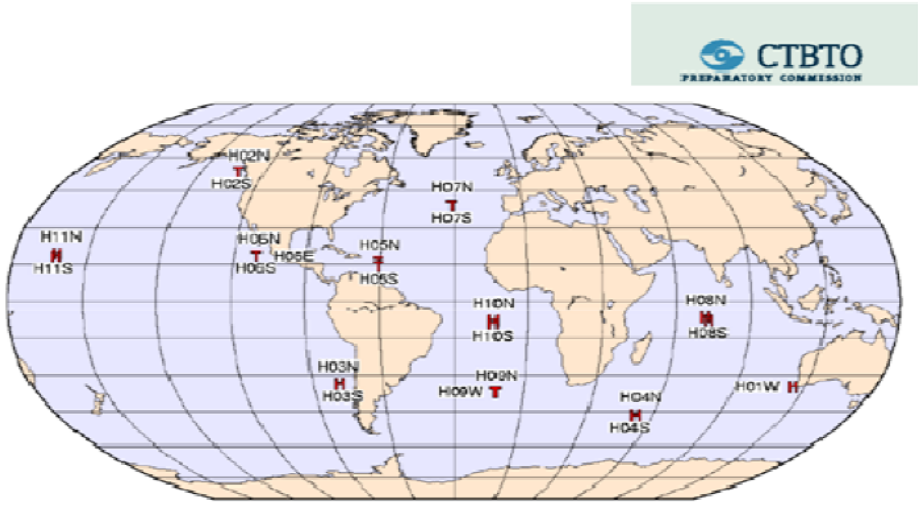
Noise Measurements

Longer time intervals were needed to evaluate the measurement methods.

Platform Location	Time start	Time end	# segments	# days	uPa / count
Ascension H10	Jan 2008	Jun 2011	1650629	1242	633.75
Cape Leeuwin H01	Jan 2008	Jun 2011	1580682	1189	642.41
Juan Fernandez H03	Jan 2007	Feb 2010	1459911	1098	648.05
Wake Island H11	Jan 2008	Jun 2011	1650603	1242	633.45

(preliminary results)

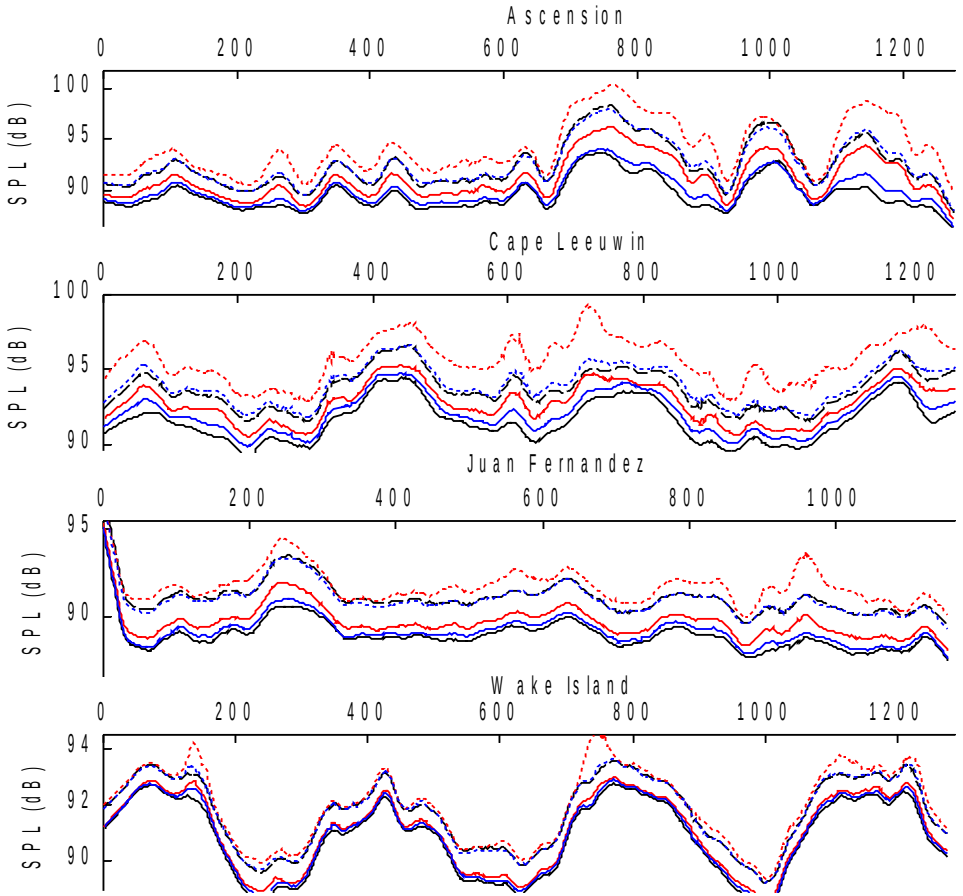


The IMS hydroacoustic network consists of 6 hydrophone triad stations and 5 land-based (so-called) T-stations

Noise Measurements

Mean estimates at CTBTO

AM – red, GM – blue, median - black



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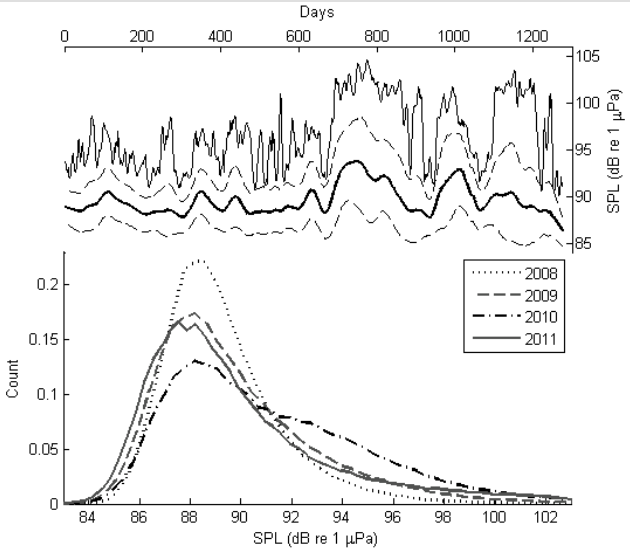
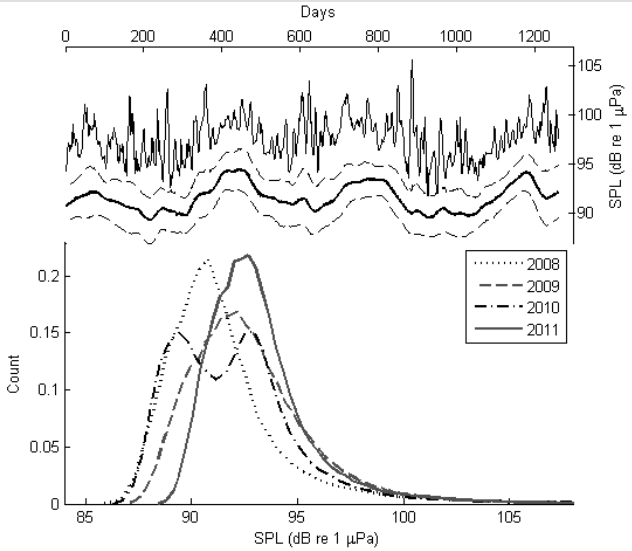
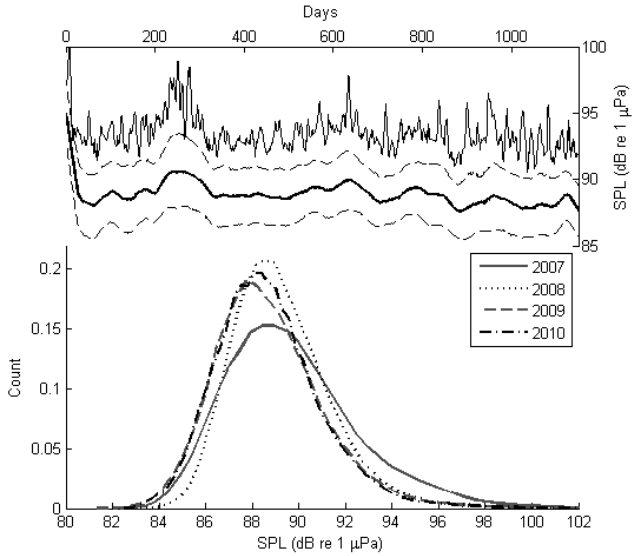
CTBTO Data



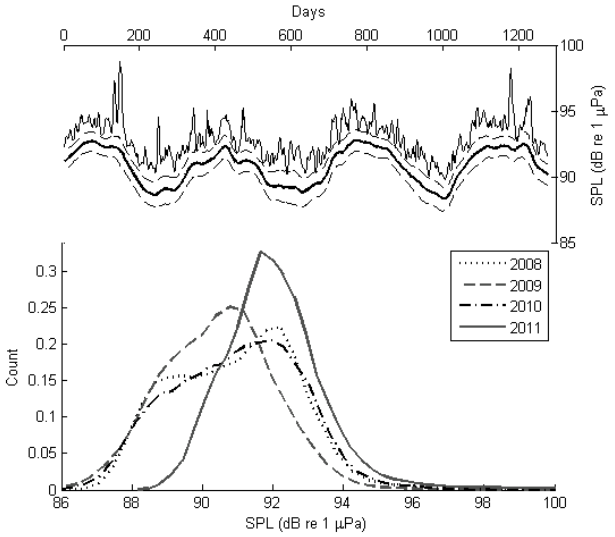
Ascension



Cape Leeuwin



Juan Fernandez



Wake Island

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Noise Measurements

Year	Median	MAD	AM	GM	std
Ascension Island					
2008	88.86	1.76	89.71	89.30	2.41
2009	89.05	2.44	90.55	89.80	3.24
2010	90.28	3.11	92.10	91.10	3.88
2011	88.89	2.86	91.02	89.92	3.86
Cape Leeuwin					
2008	90.93	2.03	92.16	91.50	2.93
2009	92.31	2.22	93.47	92.80	3.04
2010	91.72	2.38	92.91	92.04	3.29
2011	92.75	1.82	93.71	93.21	2.60
Juan Fernandez					
2007	89.31	2.25	90.26	89.70	2.92
2008	88.98	1.69	89.62	89.27	2.25
2009	88.46	1.87	89.19	88.76	2.51
2010	88.47	1.75	89.01	88.68	2.29
Wake Island					
2008	91.04	1.50	91.19	90.96	1.88
2009	90.49	1.30	90.66	90.47	1.69
2010	91.06	1.51	91.21	90.98	1.90
2011	91.94	1.13	92.26	92.08	1.61

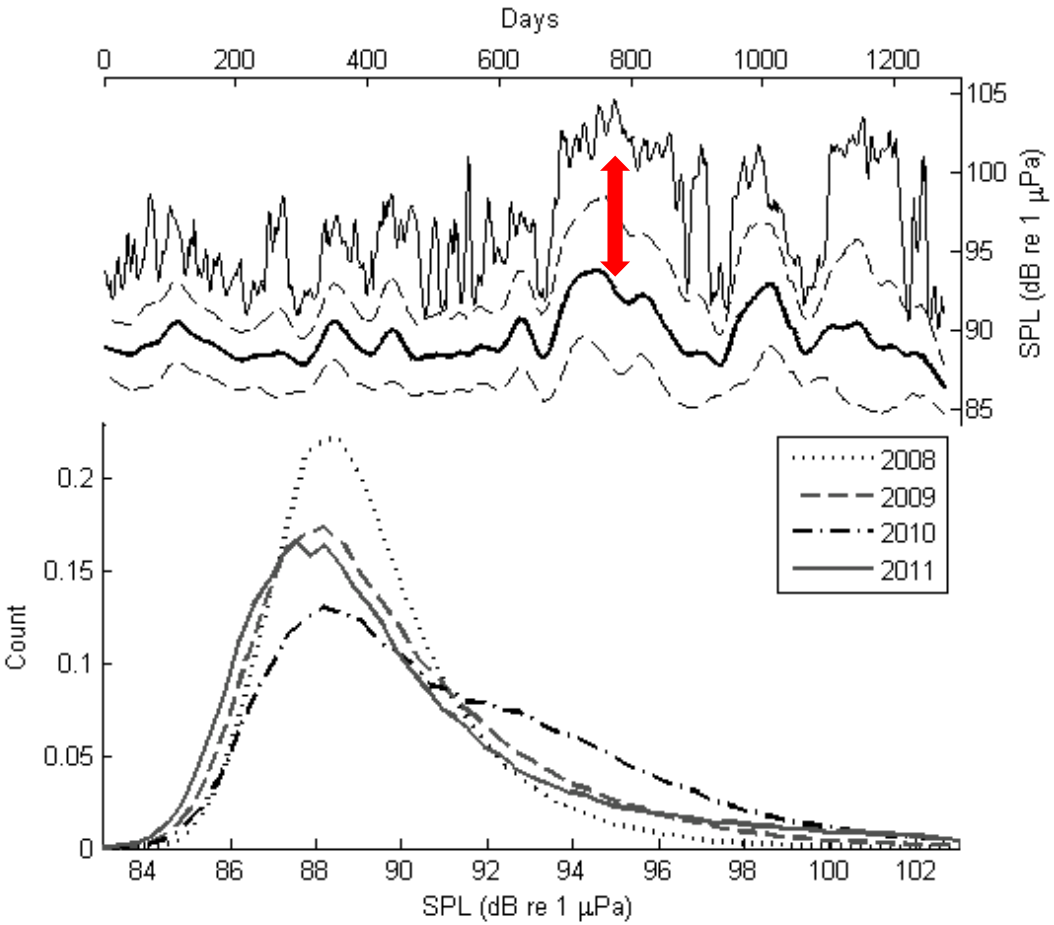
Noise Measurements

A single threshold is good for regulation, but we need a way to measure the contribution of a source. This could then be linked to a temporary change in cetacean behaviour.

The noise contribution should be compared to the ‘common’ noise levels in the area.

Noise Measurements

Measurement of noise contribution



Conclusion

- The measurement of noise at 63 and 125 Hz together with a yearly arithmetic mean will be used for MSFD11.2.
- Some attention should be given to the data distribution (multimodal) for the interpretation of a yearly value.
- To estimate ‘common’ background noise levels there is no decision yet on median or arithmetic mean. This will be important for trend estimation.
- How to quantify noise contribution is open for debate.

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